HOT-FILL BOTTLE HAVING FLEXIBLE PORTIONS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Provisional Application No. 60/558,790, filed on April 1, 2004 and also claims priority to a United States patent application entitled "Hot-Fill Bottle Having Flexible Portions" having docket no. CNST-3580 filed on March 28, 2005, which also claims the benefit of United States Provisional Application No. 60/558,790, filed on April 1, 2004, the disclosures of which are incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

[0002] This invention relates to containers, and more particularly to hot fillable containers having flexible portions to absorb vacuum.

BACKGROUND OF THE INVENTION

[0003] Perishable beverage and food products are often placed into containers at elevated temperatures. In a conventional hot-fill process, the liquid or flowable product is charged into a container at elevated temperatures, such as 180 to 190 degrees F, under approximately atmospheric pressure. Because a cap hermetically seals the product within the container while the product is at the hot-filling temperature, hot-fill plastic containers

are subject to negative internal pressure (that is, relative to ambient pressure) upon cooling and contraction of the products and any entrapped air in the head-space.

[0004] It has been a goal of conventional hot-fill container design to form stiff cylindrical portions (in transverse cross section) that maintain a cylindrical shape upon cooling. Thus, conventional hot-fill containers include designated flexing portions -- vacuum panels -- that deform when subject to typical hot-fill negative internal pressures. The inward deflection of the vacuum panels tends to equalize the pressure differential between the interior and exterior of the container – that is, absorb vacuum -- so as to enhance the ability of the cylindrical sections to maintain an attractive shape, to enhance the ease of labeling, or like commercial appeal. Some container designs are symmetric about a longitudinal centerline and designed with stiffeners to maintain the intended cylindrical shape while the vacuum panels deflect. For example, United States Patent Numbers 5,178,289, 5,092,475, and 5,054,632 teach stiffening portions or ribs to increase hoop stiffness and eliminate bulges while integral vacuum panels collapse inwardly. United States Patent Number 4,863,046 is designed to provide volumetric shrinkage of less than one percent in hot-fill applications.

[0005] Other containers include a pair of vacuum panels, each of which has an indentation or grip portion enabling the container to be gripped between a user's thumb and fingers. For example, United States Patent Number 5,141,120 teaches a bottle having a hinge continuously surrounding a vacuum panel, which includes indentations for gripping. In response to cooling of the container contents, the hinge enables the entire vacuum panel to collapse inwardly. United States Patent Number 5,141,121 similarly teaches a bottle having an outward bulge that inverts in response to cooling of the container contents. Each of the patents referred to herein by patent number is incorporated by reference in its entirety.

[0006] It has been observed that for some containers undergoing vacuum conditions, inward deflection of portions of the container, such as panels, causes regions circumferentially spaced apart from the panels to deflect outwardly. For example, some containers having opposing handgrips, which may tend to deflect inwardly upon vacuum conditions, have label panels that may deflect outwardly under vacuum conditions.

[0007] Also, some containers are subject to creasing. For example, edges of a flex panel may locally bulge outwardly after hot-filling, which is unattractive.

SUMMARY OF THE INVENTION

[0008] In accordance with one preferred embodiment of the present invention, there has now been provided a hot-fillable container including a neck portion, an enclosed bottom portion and a body portion disposed between the neck portion and the bottom portion. The body portion has flex panels disposed about the circumference of the body portion. The flex panels include a recessed central panel and a rim extending along a periphery of the central panel. The central panels are capable of inward deflection in response to the hot-filling process. A support structure fields is interposed between adjacent flex panels, and is also capable of inward deflection in response to the hot-filling process. The support structure field includes non-vertical ribs that abut one another along at least a portion of their length. At least some of the non-vertical ribs includes opposing ends that terminate at the rim of an adjacent flex panel.

[0009] In accordance with another preferred embodiment provided by the present invention, there has now been provided a hot-fillable container including a neck portion, an enclosed bottom portion and a body portion disposed between the neck portion and the bottom portion. The body portion includes a flex portion that has a plurality of spaced apart flex panels circumferentially disposed about the body portion and a support structure field interposed between adjacent flex panels. The support structure field includes a series of non-vertical ribs that abut one another along at least a substantial portion of their lengths so as to define non-vertical hinges that are capable of facilitating radial deflection of the support structure field.

[0010] In accordance with yet another preferred embodiment of the present invention, there has now been provided a hot-fillable container including a neck portion, an enclosed bottom portion and a body portion disposed between the neck portion and the bottom portion. The body portion includes a flex portion that has a plurality of spaced apart flex panels and ribbed regions. The maximum magnitude of radially inward deflection of a central panel of each of the flex panels is substantially equivalent to the maximum magnitude of raidally inward deflection of each of the ribbed regions in response to a pressure differential of about 5 psi between an exterior and interior of the container.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is a perspective view of a container;

[0012] Figure 2 is a side view of the container of Figure 1;

[0013] Figure 3 is a longitudinal cross sectional view of the container of Figure 2 taken through line 3-3;

[0014] Figure 4A is a cross sectional view normal to the longitudinal cross sectional view taken through line 4A-4A;

[0015] Figure 4B is a cross sectional view normal to the longitudinal cross sectional view taken through line 4B-4B;

[0016] Figure 4C is a cross sectional view normal to the longitudinal cross sectional view taken through line 4C-4C;

[0017] Figure 5A is a schematic view of an alternative embodiment of a portion of the container of Figure 1;

[0018] Figure 5B is a schematic view of an alternative embodiment of a portion of the container of Figure 1;

[0019] Figure 5C is a schematic view of an alternative embodiment of a portion of the container of Figure 1;

[0020] Figure 5D is a schematic view of an alternative embodiment of a portion of the container of Figure 1;

[0021] Figure 6 is a (calculated) graphical depiction of the stresses formed in the container of Figure 1 as a result of a conventional hot-filling process;

[0022] Figure 7 is an enlarged view of the graphical depiction of Figure 5;

[0023] Figure 8 is an enlarged (calculated) graphical depiction of the deformation formed in the container of Figure 1 as a result of a conventional hot-filing process.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0024] A container 10 suitable for hot-filling includes a neck portion 12, a bottom portion 18, and a body portion 22. As best shown in Figures 1 and 2, neck portion 12 includes a finish 14 for receiving a closure (shown schematically in Figure 2) and a dome 16. Preferably, container 10 is for holding a beverage, although container 10 and the principles disclosed herein may be employed for containers of any variety and for any product. Preferably, container 10 is formed of any plastic suitable for hot-filling, including, for example, polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polyethylene naphthalate (PEN), or a blend comprising the same. A perform can

be made by injection molding the plastic into an injection mold. The perform is then stretched and blown into a shaped blow mold to form a container. The present invention is not limited to the above-listed exemplary materials or processes.

[0025] Bottom portion 18 includes a heel 19 that extends downwardly from body portion 22 to a standing ring 20. A base 21, as shown in Figure 3, is a reentrant portion that extends inwardly and upwardly from standing ring 20. The present invention encompasses employing any type or configuration of finish 14, dome 16, heel 19, standing ring 20, and base 21. Preferably, dome 16 is suitable for receiving a label, such as a shrink-wrapped label 17a shown schematically in Figure 2.

[0026] Body portion 22 preferably includes a label portion 24 and a separate flex portion 26. Body portion 22 is essentially separated from dome 16 by a deep, circumferential groove 28 that provides hoop strength to the surrounding region. A label 17b, as partially schematically indicated in Figure 2, preferably wraps around the circumference of label portion 24.

[0027] Label portion 24 preferably has a round cross section that is interrupted only by circumferential ribs 30 that provide hoop strength to the label portion 24. Circumferential ribs 30 are not required to be as deep as groove 28, although the present invention is not limited to any particular relationship between groove 28 and ribs 30, or even to existence of such groove and ribs. Label 17b preferably, for aesthetic reasons, covers circumferential ribs 30.

[0028] Flex portion 26 preferably is disposed below label portion 24 to facilitate ease of labeling and gripping. Preferably, flex portion 26 is not covered with a label. Flex portion 26 includes plural flex panels 34 and support structure fields 36. Preferably, container 10 has at least three flex panels (as shown in the figures) although the present invention encompasses employing any number of flex panels according the particular parameters of the application (such as bottle diameter, wall thickness, hot-filling conditions, desired vacuum absorption, and the like).

[0029] Each flex panel 34 includes a rim 40, a central panel 42, and a recess sidewall 44. Rim 40 preferably comprises a pair of opposing lateral rims 46a and 46b, a top rim 48a, and a bottom rim 48b. Preferably, rim components 46a, 46b, 48a, and 48b are continuous, and formed by a thin, uniform strip or border.

[0030] Recess sidewall 44 preferably comprises a pair of opposing lateral recess walls 50a and 50b that extend from opposing edges of central panel 42 to lateral rims 46a and 46b, respectively. Similarly, a top recess wall 52a and a bottom recess wall 52b

extend between top and bottom edges of central panel 42 to top rim 48a and bottom rim 48b, respectively.

[0031] Central panel 42 preferably is substantially flat in its as-molded state, and has rounded corners. Accordingly, rim 40 and recess sidewall 44 have rounded corners to essentially match the outline of central panel 42. Preferably, the plane of central panel 42 is parallel to the longitudinal axis of container 10. Such orientation, while not essential, enables lateral recess walls 50a and 50b to be approximately uniform in radial dimension, which may enhance the reinforcing function of recess sidewall 44.

[0032] Support structure field 36 preferably spans between rims 40 of adjacent flex panels 34, and includes non-vertical supports, such as flex area ribs 56. As shown in the figures, ribs 56 may be formed by multiple concave (as viewed from inside container 10) outer portions 58, each of which has an upper and lower inwardly directed end 60. An end 60 of one rib 56 joins an end 60 of an adjacent rib 56 at a ridge 62.

[0033] Preferably, at least some of the circumferential ends of flex area ribs 56 are disposed proximate to or in contact with lateral rims 46a, 46b of flex panel 34. Such configuration may support lateral rims 46a, 46b and may prevent deformation of rims 46a, 46b under vacuum conditions, and may also inhibit creasing. Such configuration is not essential – rather, the present invention encompasses any configuration set forth in the claims.

[0034] Flex ribs 56 are illustrated in the figures as a series of concave portions 58. The invention is not limited to such configuration of ribs, but rather encompasses any non-vertical structure, such as ribs that are oriented other than horizontally. For example, Figures 5A, 5B, 5C, and 5D illustrate alternative embodiments of a pattern of supports within support structure field 36. Such structure is designated as support structures 37a, 37b, 37c, and 37d, respectively. Figure 5A schematically shows support structure 37a: a central circle or island with arcuate ribs disposed above and below. Figure 5B schematically shows support structure 37b: undulating ribs. Figure 5C schematically shows support structure 37c: arcuate ribs, which may be oriented to open downwardly. Alternatively, the arcuate ribs may open upwardly (not shown in the Figures). Figure 5D schematically shows support structure 37d: obliquely oriented ribs that are substantially straight or rectilinear in elevational view (although the oblique ribs will, of course, curve with the circumference of the container).

[0035] The flex ribs shown in the figures are not vertical, or, where the ribs are not rectilinear, the longitudinal center line or best fit line through the planar projection of

the rib is not vertical. The non-vertical structure of the ribs and spaces between ribs enhance the ability of the support structure field to bend relative to a horizontal axis even while such ribs will enhance hoop stiffness of the support structure field 36, 37a, 37b, 37c, or 37d. In this regard, the ribs of support structure field 36, 37a, 37b, 37c, or 37d stiffen such support structure field from flexing in a horizontal plane or about a vertical axis.

[0036] Figures 4A, 4B, and 4C illustrate aspects of the function of the preferred container 10. The solid lines illustrate the cross sections in the as-molded state, and the dashed lines schematically indicate the cross sections on container 10 under conventional vacuum conditions created by filling the product (not shown) at approximately 185 degrees F and then capping container 10 and allowing it to cool to room temperature. In Figures 4A , 4B, and 4C, a solid double line in the region of the flex area ribs 56 shows both concave outer portion 58 and ridge 62 as solid lines, and omits the cross sectional cross-hatching for clarity. For clarity, deformation is indicated by a single dashed line 56' is this region. Dashed line 42' indicates deformation of central panel 42 of flex panel 34.

[0037] Central panels 42 of the flex panels 34 deform inwardly, as expected. As best shown in Figure 4B, the centers of the regions between the flex panels (that is, in support structure field 36) also deflect inward to absorb vacuum. Figure 4A, which shows the cross section near an upper end of flex portion 26, shows a relatively small magnitude of inward deflection upon vacuum. Similarly, Figure 4C, which shows the cross section near a lower end of flex portion 26, also shows a relatively small magnitude of inward deflection upon vacuum. Preferably, and in order to enhance the total magnitude of vacuum absorption, the magnitude of maximum inward deflection of central panel 42 is approximately the same as the magnitude of maximum inward deflection of support structure field 36. Such relative magnitudes are not essential, and the present invention encompasses any relative magnitudes of inward deflection (or even no inward deflection of the support structure fields), according to the language of the claims. It should be understood that the deflection shown by broken lines is for illustration purposes only. Actual deflection may vary in relative magnitude, geometry and/or uniformity.

[0038] The functional aspects of container 10 are further illustrated in Figures 6, 7, and 8. Figures 6 and 7 graphically show calculated von Mises stress for container 10 based on a geometric non-linear analysis using 2-D shell elements. Von Mises stress at each point is an averaged stress value calculated by adding the squares of the 3 component stresses (X, Y and Z directions) and taking the square root of their sums.

Container 10 was mathematically analyzed as a full bottle without the finish and restrained at the top surface.

[0039] Stresses were calculated based on a 5 psi vacuum. The temperature variation under vacuum performance was ignored. The wall thickness of container 10 was assumed to be 0.015 inches uniform throughout container 10, except the neck and base 21, which were presumed to be 0.050 inches thick. As best shown in Figure 7, lateral recess sidewalls 50a and 50b undergo the greatest magnitude of von Mises stress under vacuum conditions, thereby (among other things) providing stiffening and inhibiting creasing of lateral rims 48a and 48b, respectively. Ridges 62 undergo higher stress than does concave outer portion 58 of flex area ribs 56.

[0040] Figure 8 illustrates calculated deformation based on the same conditions as the calculated stresses of Figures 6 and 7. In general agreement with the stresses shown in Figure 7, central panel 42 bows inwardly, with the greatest magnitude of deformation occurring in its center.

[0041] As best shown in Figure 8, lateral recess sidewalls 50a and 50b and lateral rims 46a and 46b function as stiffeners relative to central panel 42. Also, top and bottom recess sidewalls 52a and 52b and top and bottom rims 48a and 48b act as stiffeners relative to central panel 42.

[0042] Accordingly, because the support structure field 36 undergoes inward deflection in addition to the inward deflection of the center panel 42 of flex panel 34, vacuum absorption is enhanced. The label panel portion is stiffened by ribs 30, and generally retains its circular shape to enhance labeling and appearance.

[0043] The present invention is illustrated with respect to a preferred embodiment, and the present invention is not limited to the particular structure described in the preferred embodiment of container 10. For example, the present invention encompasses a container in which a label panel (such as label portion 24 of container body 22) undergoes some deformation under vacuum conditions, becomes out-of-round under vacuum conditions, and/or is not circular in its as-molded state – even though such structure or function is not shown in the figures.

[0044] Furthermore, it is not essential that the container have separate flex portions 26 and label portions 24. For example, the present invention encompasses the body portion 22 of container 10 or (other body configuration of other container covered by the appended claims) being covered by a label (such configuration not shown in the figures). The non-mechanical and subjectively attractive appearance of body portion 22

renders it suitable for use without a label, and the flex panels 34 disposed about the circumference of container 10 enhance gripping, but such advantages are optional.

[0045] It is understood that persons familiar with hot-fill container technology will recognize additional advantages and features that flow from the present disclosure, and the present invention encompasses such additional advantages and features such that the scope of the invention is limited only by the claims.